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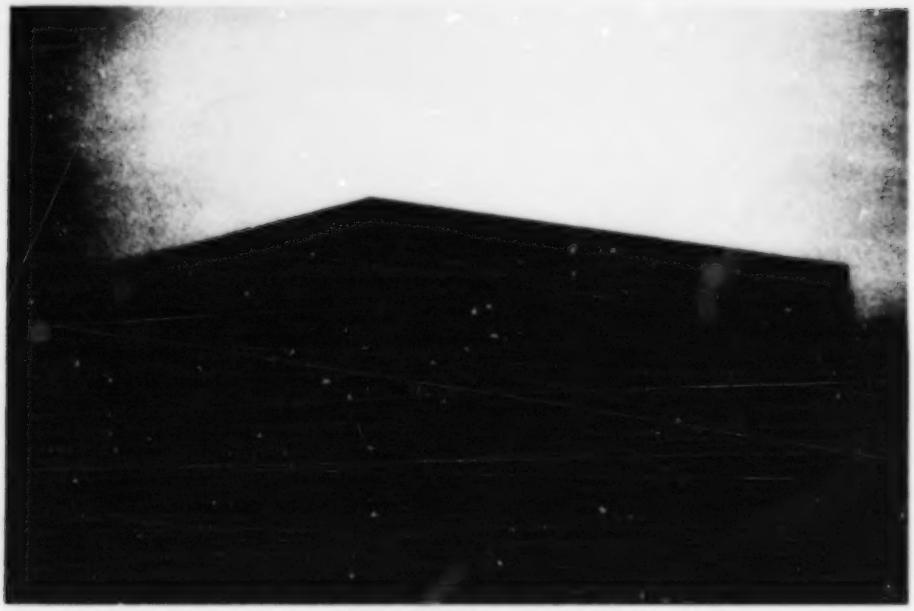

PAN AM POOL

MAN 31

URBAN RECREATION RETROFIT

MG-13175

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APRIL 1985

MANITOBA/CANADA CONSERVATION AND RENEWABLE ENERGY DEMONSTRATION AGREEMENT

The availability of secure and affordable energy supplies is a subject of national concern. It is an accepted fact that our primary energy sources — oil and natural gas — are becoming less accessible and more costly. However, Canada is well-endowed with renewable and alternative resources that can provide a bridge into the future.

To this end, the governments of Manitoba and Canada entered into a Conservation and Renewable Energy Demonstration Agreement which was signed May 9, 1980 and terminated March 31, 1984. The Agreement was dedicated to the development and demonstration of conservation and renewable energy technologies. Equally cost-shared by the provincial and federal governments, the program had a total budget of $18-million.

The objectives of CREDA are:

- To develop and demonstrate promising new technologies, which, when widely adopted, will exploit renewable resources, conserve energy and/or use energy more efficiently.
- To develop broad public awareness of the potential of renewable energy and conservation technology.
- To provide opportunities for the commercial application of the technologies within Manitoba.
- To create economic spin-off benefits for manufacturing, industry and commerce.
- To create employment in new or existing energy-related industries.

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This report is a summary of a study commissioned by Energy and Mines Manitoba and the Department of Fitness, Recreation and Sport under the Manitoba/Canada Conservation and Renewable Energy Demonstration Agreement. The intention of the Study was to investigate all methods and means of conserving energy within recreation facilities. The Consultant's role was to visit selected facilities, compile energy data, recommend and implement conservation techniques, and present seminars. The final responsibility was to write this summary report on the whole program. The information gathered from the four urban facilities studied under this program and the six rural facilities studied under another program was to be used as a guideline for all recreation facilities throughout Manitoba.

This report reviews the proposed energy conservation techniques, many of which were later implemented. It presents an overview of what energy and cost savings are projected to result.

Under the Urban Recreation Centre Retrofit Program, the Consultant analysed four recreation facilities for possible energy conservation techniques. These facilities were then retrofitted based on the Consultant's recommendations provided in the facility energy reports. It is intended that the summary data presented in this report, combined with information from the Rural Arena Retrofit Program, are to be used to form a guide for future energy conservation efforts in recreational facilities in Manitoba.

For each facility, the energy and cost savings and the retrofit implementation cost were estimated, allowing a projected simple payback period to be determined. These figures are outlined below.

THOMPSON RECREATION CENTRE	1983 Pre-retrofit energy consumption	3×10^6 kWh/a
	1983 Pre-retrofit utility cost	$90 100/a
	Projected post-retrofit energy saving	9×10^5/a (30%)
	Projected post-retrofit cost saving	$31 100/a (35%)
	Projected implementation cost	$108 000
	Simple payback period	3.5 years
BRANDON SPORTS COMPLEX	1983 Pre-retrofit energy consumption	8×10^6 kWh/a
	1983 Pre-retrofit utility cost	$142 000/a
	Projected post-retrofit energy saving	1.6×10^6 kWh/a (20%)
	Projected post-retrofit cost saving	$34 000/a (24%)
	Projected implementation cost	$89 000
	Simple payback period	2.6 years
FLIN FLON AQUA CENTRE	1983 Pre-retrofit energy consumption	1.8×10^6 kWh/a
	1983 Pre-retrofit utility cost	$49 000/a
	Projected post-retrofit energy saving	5.8×10^5 kWh/a (32%)
	Projected post-retrofit cost saving	$17 600/a (36%)
	Projected implementation cost	$120 000
	Simple payback period	6.8 years

PAN AM POOL

1983 Pre-retrofit energy consumption	10×10^6 kWh/a
1983 Pre-retrofit utility cost	$232 000/a
Projected post-retrofit energy saving	1.8×10^6 kWh/a (18%)
Projected post-retrofit cost saving	$41 000/a (18%)
Projected implementation cost	$95 000
Simple payback period	2.3 years

For all four facilities, the combined projected retrofit cost was $412 000 and expected annual savings were estimated at $124 000, yielding a projected simple payback period of 3.3 years. The retrofits are expected to give overall energy and cost savings of 21% and 24% respectively.

Many of the cost effective energy conservation techniques were common to each facility studied. For instance, most facilities with daily unoccupied periods can employ the following techniques:

- reduce space temperatures at night
- cover pool surfaces to prevent evaporation
- shut off ventilation equipment
- decrease outside air ventilation volumes.

Other cost effective techniques include:

- use off-peak electrical power for heating
- correct power factor
- improve combustion efficiency
- delamp excessively lit areas
- use heat recovery systems on ice compressors
- use heat recovery devices on supply and exhaust air streams
- Consider pool humidifiers
- employ low flow shower heads.

Although these techniques usually provide simple paybacks of less than five years, a detailed analysis is recommended for each facility to determine which techniques are the most economical. In most cases, it is advisable to seek professional help before implementing any of the techniques listed within this text.

SOMMAIRE

Dans le cadre du Programme d'amélioration des centres urbains de loisirs (Urban Recreation Centre Retrofit Program), l'expert-conseil a étudié la possibilité d'instaurer des mesures d'économie d'énergie dans quatre établissements de loisirs. Les mesures d'amélioration énergétique ont par la suite été mises en oeuvre en fonction des recommandations formulées dans le rapport de l'expert-conseil. Les données résumées figurant dans le présent rapport, ainsi que les renseignements recueillis dans le cadre du Programme d'amélioration des patinoires rurales (Rural Arena Retrofit Program), doivent par la suite servir de fondement à l'instauration d'autres mesures d'amélioration énergique dans les établissement de loisirs du Manitoba.

Les économies réalisables sur le plan financier et sur le plan énergétique, ainsi que le coût des travaux d'amélioration ont été évalués, ce qui a permis de calculer le délai de récupération à taux simple. Ces données figurent ci-après.

THOMSON RECREATION CENTRE

Consommation d'énergie, 1983 (avant amélioration)	3×10^6 kWh/an
Coûts énergétiques, 1983 (avant amélioration)	90 100 $/an
Économie prévue d'énergie (après amélioration)	9×10^5/an (30 %)
Économies prévues (après amélioration)	31 100 $/an (35 %)
Coût prévu de mise en oeuvre	108 000 $
Délai de récupération au taux simple	3,5 ans

BRANDON SPORTS COMPLEX

Consommation d'énergie, 1983 (avant amélioration)	8×10^6 kWh/an
Coûts énergétiques, 1983 (avant amélioration)	142 000 $/an
Économie prévue d'énergie (après amélioration)	$1,6 \times 10^6$/an (20 %)
Économies prévues (après amélioration)	34 000 $/an (24 %)
Coût prévu de mise en oeuvre	89 000 $
Délai de récupération au taux simple	2,6 ans

FLIN FLON AQUA CENTER

Consommation d'énergie, 1983 (avant amélioration)	$1,8 \times 10^6$ kWh/an
Coûts énergétiques, 1983 (avant amélioration)	49 000 $/an
Économie prévue d'énergie (après amélioration)	$5,8 \times 10^5$/an (32 %)
Économies prévues (après amélioration)	17 600 $/an (36 %)
Coût prévu de mise en oeuvre	120 000 $
Délai de récupération au taux simple	6,8 ans

PAN AM POOL

Consommation d'énergie, 1983 (avant amélioration)	10×10^6 kWh/an
Coûts énergétiques, 1983 (avant amélioration)	232 000 $/an
Économie prévue d'énergie (après amélioration)	$1,8 \times 10^6$/an (18 %)
Économies prévues (après amélioration)	41 000 $/an (18 %)
Coût prévu de mise en oeuvre	95 000 $
Délai de récupération au taux simple	2,3 ans

Le coût total prévu des améliorations à apporter aux quatre établissements s'élevait à 412 000 $, avec des économies annuelles prévues de 124 000 $, d'où un délai de récupération au taux simple de 3,3 ans. Les améliorations doivent pouvoir permettre de réaliser des économies d'énergie et des baisses de dépenses de 21 % et de 24 % respectivement.

Un bon nombre des mesures efficaces d'économie d'énergie s'appliquaient tout aussi bien à chacun des établissements faisant l'objet de l'étude. Par exemple, la plupart des établissements où l'on compte quotidiennement des périodes libres peuvent adopter les techniques suivantes:

- réduction de la température ambiante la nuit;
- recouvrement des piscines pour empêcher l'évaporation;
- arrêt des systèmes d'aération;
- baisse du volume d'air puisé à l'extérieur.

Parmi les autres mesures efficaces, on compte notamment:

- utilisation du chauffage électrique en dehors des heures de pointe;
- correction du facteur de puissance;
- amélioration de l'efficacité de combustion;
- coupures d'éclairage dans les lieux trop éclairés;
- récupération de la chaleur dégagée par les compresseurs de réfrigération;
- installation de dispositifs de récupération de la chaleur sur les canalisations d'arrivée et de sortie d'air;
- installation d'humidificateurs de piscine;
- installation de douches à faible débit.

Quoique les techniques suggérées appellent en général des délais de récupération à taux simple de moins de cinq ans, il est recommandé de soumettre chaque établissement à une analyse approfondie qui permettrait de définir les techniques les plus efficaces pour chaque cas particulier. Dans la plupart des cas, il est préférable de consulter les spécialistes avant d'instaurer les mesures énoncées dans le présent document.

Introduction

Funding for the Urban Recreation Centre Retrofit Program was provided jointly by the Provincial and Federal governments and the respective cities, up to a limit of $100 000 per project. Any additional funds beyond this limit were contributed by the cities.

The four urban facilities studied under the program were:

1. Thompson Recreation Centre

This indoor arena facility is located in the northern part of the province. The facility consists of one heated arena, one non-heated arena and a gymnasium. This complex is used extensively throughout the year for many sports and activities

2. Brandon Sports Complex

This is a multipurpose facility located in the south-western portion of the province. The facility includes an indoor swimming pool, a heated arena and racquetball courts.

3. Flin Flon Aqua Centre

This centre is located in the mid-western part of the province. The facility consists of an indoor swimming pool and a small amenities area.

4. Pan Am Pool

The Pan Am Pool is located in Winnipeg and was constructed for the 1967 Pan American Games. It has an indoor olympic size pool and a large amount of art display area. The facility continues to host world class swimming competitions.

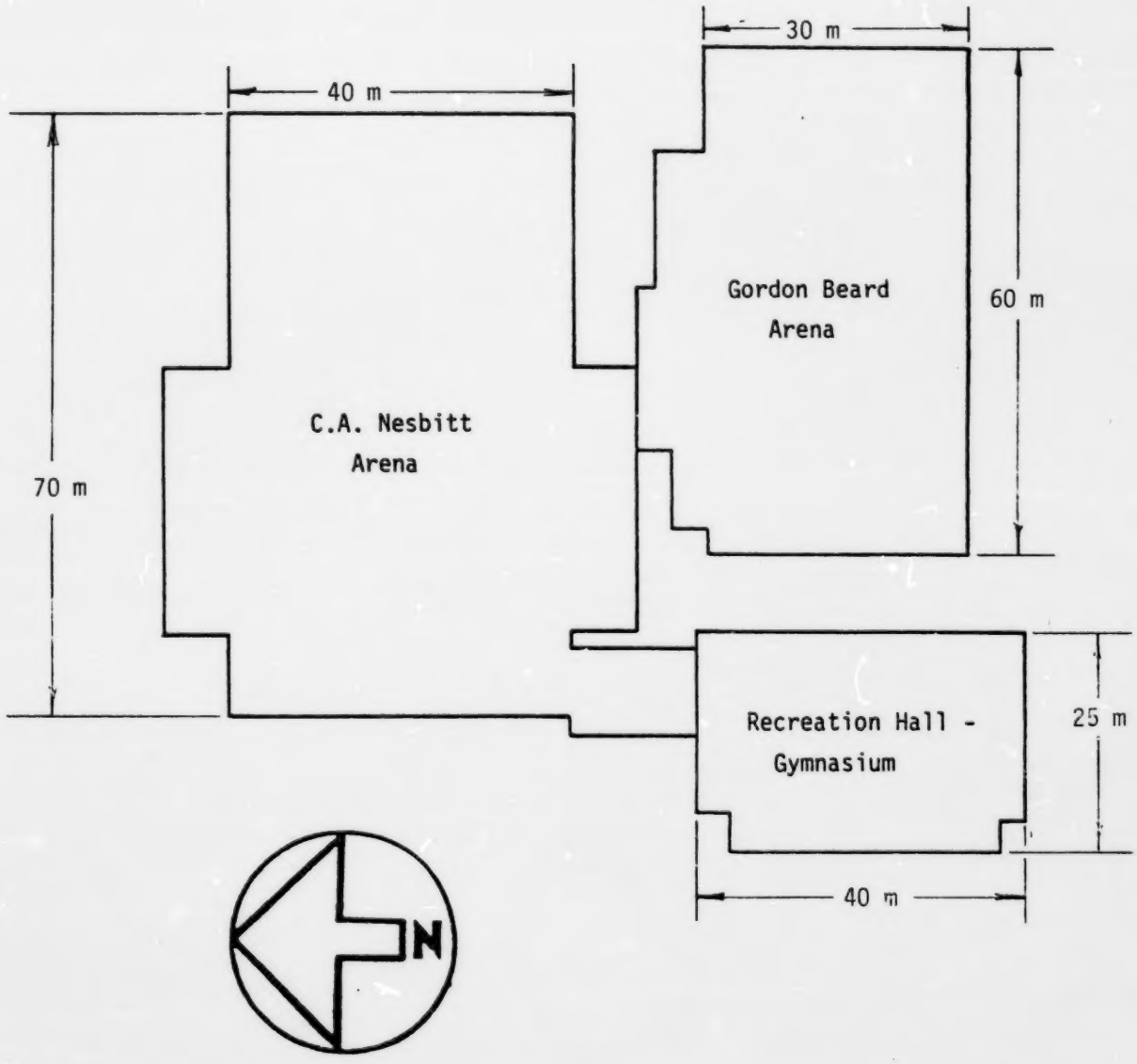
Each of the four urban recreation facilities studied is outlined briefly in one of the following four sections. For each facility, the following are illustrated: its pre-retrofit energy cost and consumption characteristics, the proposed energy conservation techniques (ECTs) and the resulting projected energy and cost savings. In general,

an ECT was accepted if it had a simple payback of less than five years. General conclusions are drawn at the end of the report.

An indepth energy study is required for the optimum selection of conservation techniques in any facility. Each facility represents a unique combination of location, fuel service, fuel utilization, and architectural, mechanical and electrical systems. These all affect energy consumption and costs. Therefore, generalization of ECTs listed in this report for application to all Manitoba facilities is not recommended. However, all facilities have some common characteristics and readers are urged to investigate those techniques outlined in this report that may be compatible with their facilities. It is intended that this report suggest a start and direction for all Manitoba recreation facility operators wishing to conserve energy and reduce their energy costs.

Much of the data in this text was obtained from detailed reports written for each facility. Any information beyond the scope of this summary report can be obtained from Energy and Mines Manitoba, or E.J. Faraci and Associates Ltd. At present, the retrofits have been implemented but no actual savings data are yet available. The facilities' post-retrofit energy costs and consumption will be monitored and should be made available at a future date. Commonly occuring energy conservation techniques have been presented as case studies in the Appendix.

1. Thompson Recreation Centre



PLAN VIEW
THOMPSON RECREATION CENTRE
N.T.S.

FIGURE 1.1

Propane and electricity are the two energy sources for the Thompson Recreation Centre. The 1983 pre-retrofit energy cost for the complex was $90 100. The energy consumption, in the range of 2.5 to 3.5 million kW.h annually, was divided equally between the two energy sources as shown in Table 1.1 and illustrated in Figure 1.2.

The Centre is an extremely well-run and well-maintained facility which offers a wide variety of sports activities. Nevertheless, the Consultant was able to discover some specialized methods of saving energy and reducing energy costs. The fifteen energy conservation techniques that were evaluated are summarized in Table 1.2. For each ECT, the estimated implementation cost, the energy and cost savings, the simple payback, and the Consultant's recommendation are listed. Also, it is noted in Table 1.2 whether or not the ECT was implemented by the facility.

As shown in Table 1.2, fifteen ECTs were evaluated. Of these, the Consultant recommended eleven be implemented. These are described briefly below.

ECT 1 Maintenance Procedures

Daily, weekly, monthly, yearly and general maintenance procedures should be carried out.

ECT 2 Heating with Propane vs. Electricity

At the current rates, heating with propane is favoured over electric heat.

ECT 3 Propane Rates

There are two different propane rate scales. The propane consumer should check his own particular consumption and be sure that he is on the more economical scale.

ECT 4 Low Flow Shower Heads

Restrictors placed on shower heads reduce hot water consumption.

ECT 6 Night Setback

Energy is saved by lowering the space temperature during any unoccupied hours.

ECT 7 Reduction of Electric Unit Heater Size

Reducing the size of one's electric unit heaters decreases the demand charge portion of one's electricity bill.

ECT 9 Infiltration Reduction

Sealing and caulking the structure reduces infiltration losses.

ECT 11B Heat Reclaim

In the Nesbitt ice rink, hot ammonia gases are discharged from the compressor to be cooled in the cooling tower. With the addition of an ammonia-to-water heat exchanger, the heat can be used for domestic hot water heating and space heating of the Nesbitt Arena.

ECT 13 Power Factor Correction

Adding capacitors to large motors or to the electrical service reduces the demand charge portion of the electricity bill.

ECT 14 Arena Lights

The lighting in the Nesbitt Arena can be upgraded and the Gordon Beard Arena relamped with new fixtures.

ECT 15A Electric Heating for the Lobby

Heating with electricity at the low run-out rate is more economical than using propane. The lobby of the Nesbitt Arena should be heated with electricity.

All eleven recommended ECTs have been implemented. The resulting retrofit is summarized below:

Projected post-retrofit energy saving	8.88×10^5 kW.h/a(30%)
Projected post-retrofit cost saving	$31 100/a (35%)
Projected implementation cost	$108 000
Simple Payback Period	3.5 years

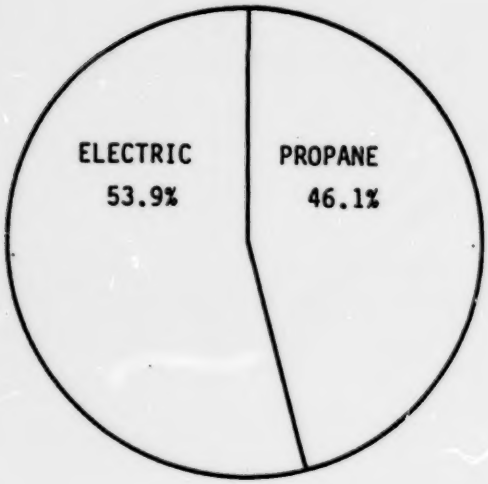
Figure 1.2 illustrates the expected savings in energy consumption and cost.

Reclaiming heat energy from the ice plant and sequencing electrical loads both realized major savings and were typical of all facilities as explained further in the Conclusion.

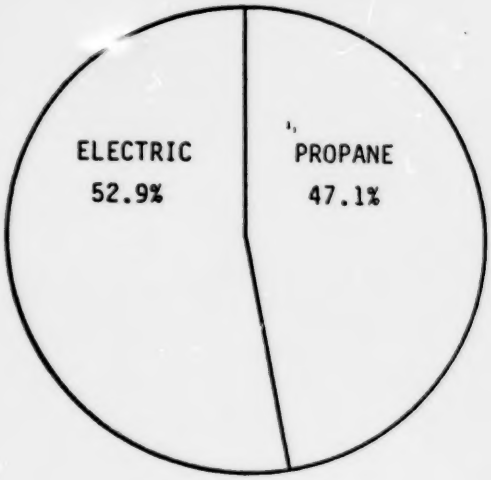
TABLE 1.1 - 1983 PRE-RETROFIT ENERGY CONSUMPTION DATA - THOMPSON RECREATON CENTRE

LOCATION	ELECTRICITY CONSUMPTION					PROPANE CONSUMPTION			TOTAL CONSUMPTION
	DHW kW.h	Space Heat kW.h	Lights kW.h	Power kW.h	Total kW.h	DHW kW.h	Space Heat kW.h	Total kW.h	kW.h
Gordon Beard Arena	-	367 800	157 000	261 400	786 200	79 910	-	79 910	866 110
C.A. Nesbitt Arena	26 300	147 840	229 900	374 160	778 200	95 860	753 530	849 390	1 627 590
Recreation Hall	-	3 240	54 600	12 250	70 090	39 520	431 280	470 800	540 890
Total	26 300	518 880	441 500	647 810	1 634 490	215 290	1 184 810	1 400 100	3 034 590

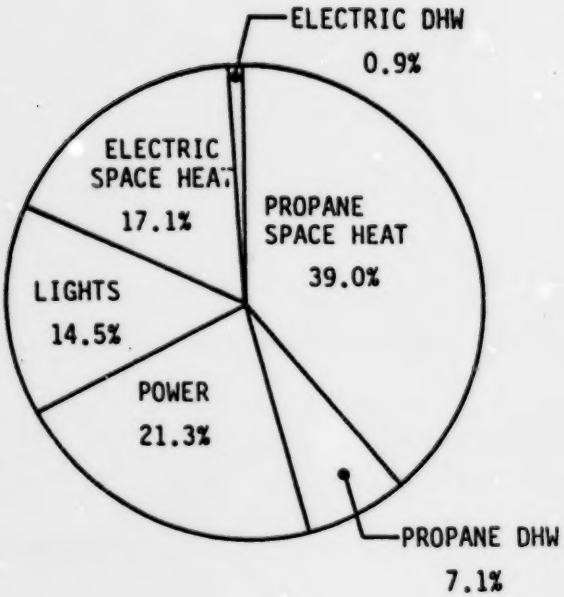
1983 PRE-RETROFIT ENERGY CONSUMPTION



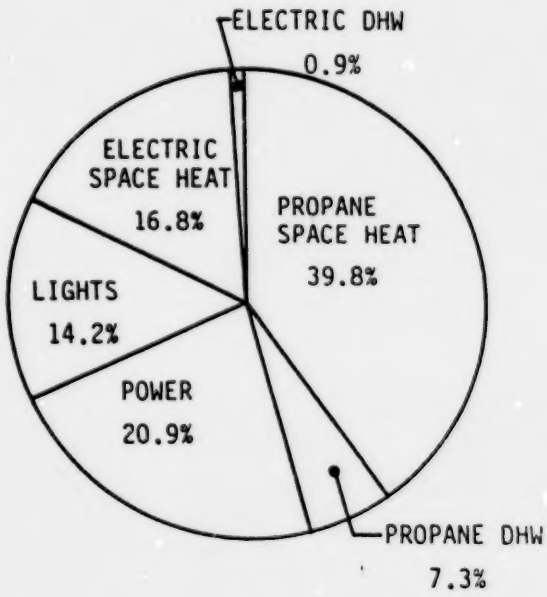
1983 PRE-RETROFIT ENERGY COST



1983 PRE-RETROFIT COMPONENT ENERGY CONSUMPTION



1983 PRE-RETROFIT COMPONENT ENERGY COST



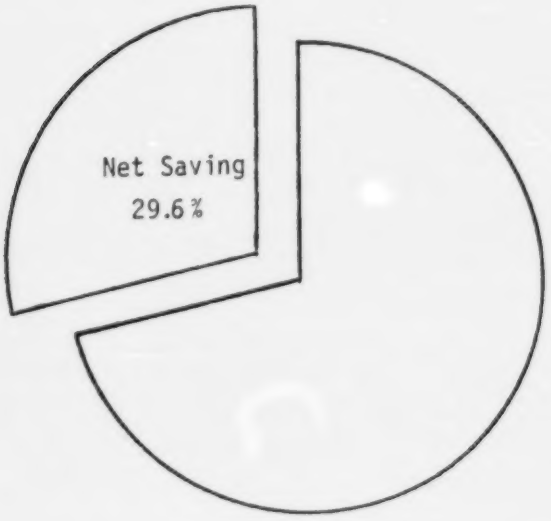
PRE-RETROFIT ENERGY USAGE
THOMPSON RECREATION CENTRE

FIGURE 1.2

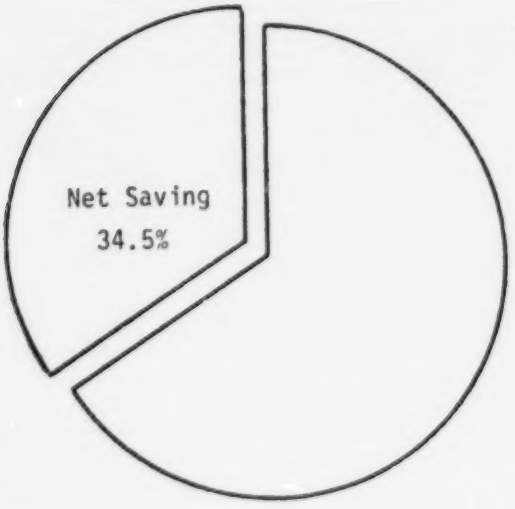
TABLE 1.2 - SUMMARY OF ENERGY CONSERVATION TECHNIQUES DATA - THOMPSON RECREATION CENTRE

ECT	DESCRIPTION	ESTIMATED CAPITAL COST ($)	ENERGY SAVING (kWh/A)	COST SAVING ($/A)	SIMPLE PAYBACK (yrs)	CONSULTANT'S RECOMMENDATION	IMPLEMENTED
1	Maintenance Procedures	-	-	-	-	Y	Y
2	Heating with Propane vs. Electric	-	-	-	-	Y	Y
3	Propane Rates	-	-	-	-	Y	Y
4	Low Flow Shower Heads	320	58 105	2 012	0.2	Y	Y
5	Delamping	-	-	-	-	N/A	N/A
6	Night Setback	2 000	13 513	500	4	Y	Y
7	Reducing Electric Unit Heater Size	500	-	3 352	0.2	Y	Y
8	Lower Gymnasium Ceiling	16 900	46 400	1 288	13.1	N	N
9	Infiltration Reduction	19 900	147 919	5 473	3.4	Y	Y
10	Insulation	35 425	98 110	3 630	9.8	N	N
11A	Brine Storage	25 000	5 772	1 153	21.7	N	N
11B	Heat Reclaim	61 200	632 111	16 590	3.7	Y	Y
12	Consolidation of Electrical Meters	48 000	-	2 010	21.4	N	N
13	Power Factor Correction	3 860	-	1 102	3.5	Y	Y
14	Arena Lights	15 200	Limited	Facility	Upgrading	Y	Y
15A	Electric Heating for Lobby	4 500	36 000	2 075	2.2	Y	Y
15B	Electric Domestic Water Heating	4 050	13 330	770	5.3	N	N
TOTALS	Implemented ECTs	$108 000	888 000	$31 100	3.5 years	-	Y
	Consultant's Recomm. ECTs	$108 000	888 000	$31 100	3.5 years	Y	-

PROJECTED POST-RETROFIT ENERGY SAVING



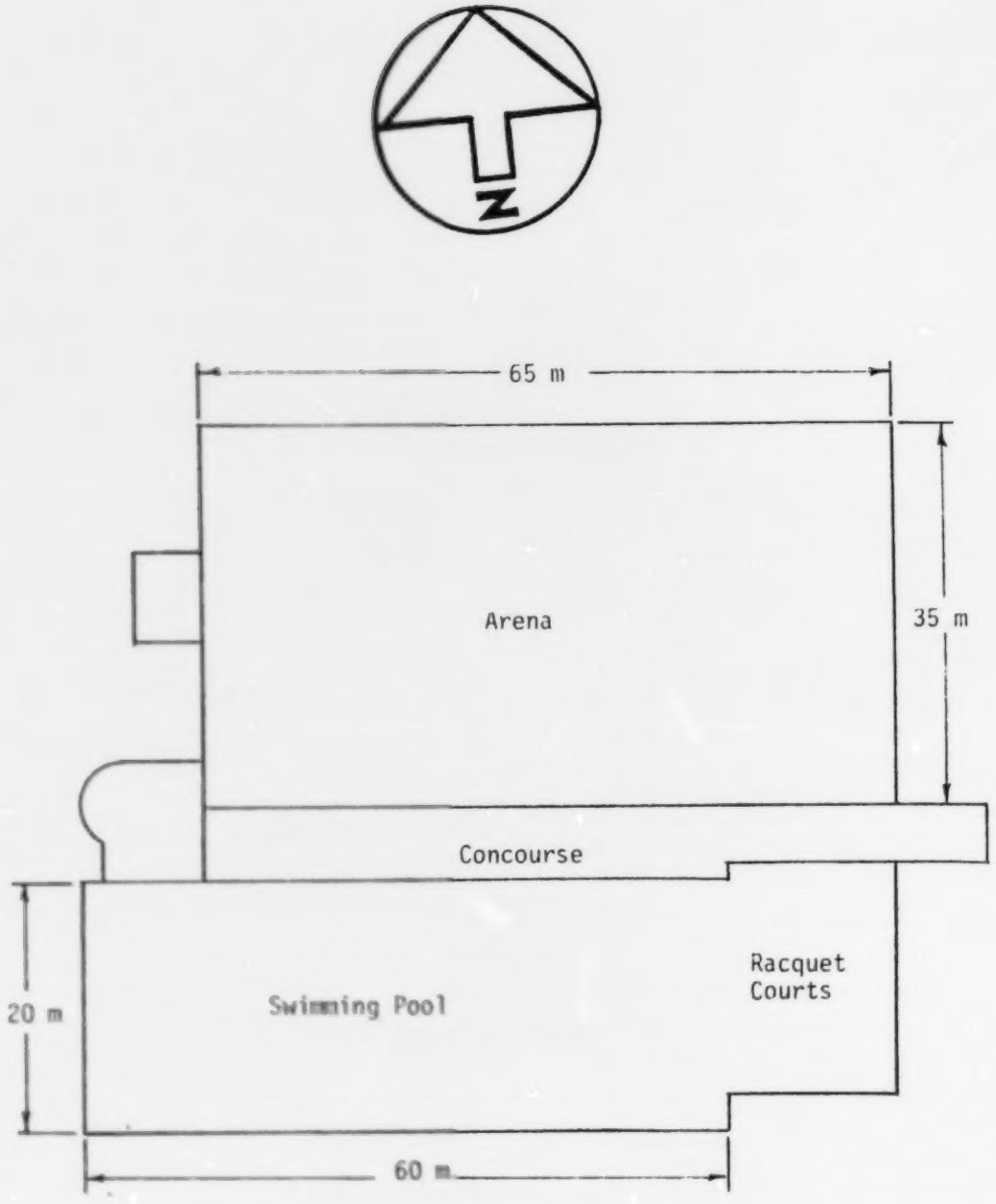
PROJECTED POST-RETROFIT COST SAVING



PROJECTED POST-RETROFIT SAVINGS
THOMPSON RECREATION CENTRE

FIGURE 1.3

2. Brandon Sports Complex



PLAN VIEW

BRANDON SPORTS COMPLEX

N.T.S.

FIGURE 2.1

Natural gas and electricity are the two sources of energy for the Brandon Sports Complex. The 1983 pre-retrofit energy cost for the complex was $142 000. Its historical consumption of energy is 8 to 10 million kW.h annually, of which 75% was in the form of natural gas. The unit cost of natural gas is less than that of electricity and as a result, natural gas accounted for only 63% of the total energy bill. The energy distribution is listed in Table 2.1 and illustrated in Figure 2.2.

Twenty energy conservation techniques were evaluated. The results are summarized in Table 2.2. The eleven recommended ECTs are described briefly below.

ECT 1 Maintenance Procedures

Daily, weekly, monthly, yearly and general maintenance procedures should be carried out.

ECT 2 Pool Filter Backwashing

Improving the technique of cleaning the pool sand filters conserves the heated, chemically-treated water.

ECT 3 Demand Load Limiting on Icemaking Compressors

Using one compressor whenever possible minimises the peak demand for electricity.

ECT 4 Infiltration Reduction

Sealing and caulking the structure reduces the infiltration losses.

ECT 8 Conservation of Water Used to Cool Ice Compressors

The method of storing and then re-using the water used to cool the ice compressors results in a great deal of wasted hot water. This arrangement can be modified to put more of this hot water to good use.

ECT 10 Delamping in Receptionists' Area

The electricity bill is reduced by using less lighting.

ECT 14 Electric Boiler

Installing an electric boiler enables electricity to be used, at the low run-out rate, which is more economical than natural gas.

ECT 15B Heat Reclaim

In the refrigeration equipment, hot ammonia gases are discharged from the compressor to be cooled in the cooling tower. These gases can first be used to heat glycol in a heat exchanger which can heat the domestic hot water, pool water, and outside ventilation air for the pool area.

ECT 19 Energy Management System

A microprocessor and direct digital control optimises the functions of mechanical equipment. This causes savings all around as a result of overall increased efficiency.

ECT 20 Power Factor Correction

Adding capacitors to large motors or to the electricity service reduces the demand charge portion of the electricity bill.

ECT 19 (The Energy Management System) encompasses ECT 5,6 and 9; these are explained briefly below.

ECT 5 Kitchen Exhaust

The kitchen ventilation system should be operated only when the area is occupied. This prevents unnecessary heating and cooling of outside air.

ECT 6 Swimming Pool Recirculation Pump

The pool recirculation pump should be turned off when the pool is not being used.

ECT 9 Night Setback

Energy is saved by lowering the space temperature during any unoccupied hours.

All eleven recommended ECTs were implemented. The resulting retrofit is summarized below.

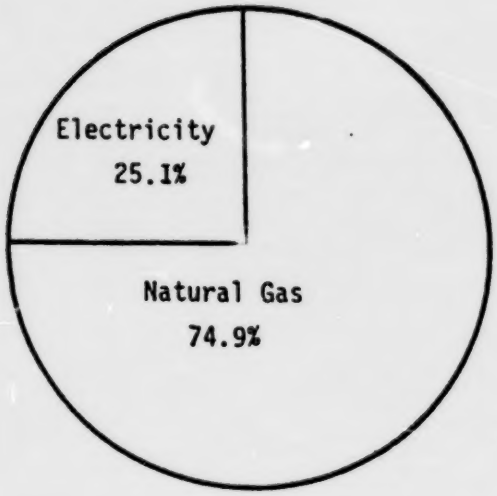
Projected post-retrofit energy saving	1.6×10^6 kW.h/a(20%)
Projected post-retrofit cost saving	$34 000/a (24%)
Projected implementation cost	$89 000
Simple Payback Period	2.6 years

Figure 2.3 illustrates the expected savings in energy consumption and cost.

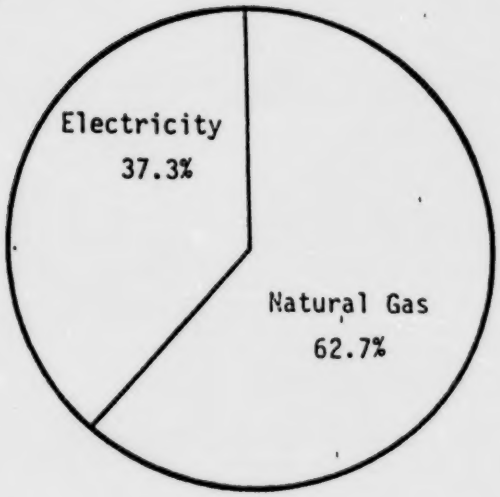
TABLE 2.1 - 1983 PRE-RETROFIT ENERGY CONSUMPTION DATA - BRANDON SPORTS CENTRE

CONSUMPTION SOURCE	ELECTRICITY CONSUMPTION			GAS CONSUMPTION			TOTAL CONSUMPTION
	LIGHTS KWH	POWER KWH	TOTAL KWH	SPACE HEAT KWH	DHW KWH	TOTAL KWH	KWH
Pool	168,670	436,860	605,530	2,638,400	-	2,638,400	3,243,930
Arena	104,580	635,260	739,840	2,335,000	-	2,335,000	3,074,840
Racquet Courts	48,490	68,620	117,110	369,900	-	369,900	487,010
Concourse	146,730	64,830	211,560	855,600	-	855,600	1,067,160
Crawl Space	N/A	3,810	3,810	132,900	-	132,900	136,710
General	-	121,830	121,830	-	-	-	121,830
Miscellaneous	-	180,000	180,000	-	245,714	245,714	425,714
1/3 Electrical Internal Heat Gain	-	-	-	-659,900	-	-659,900	-659,900
TOTAL	468,470	1,511,210	1,979,680	5,671,900	245,714	5,917,614	7,897,294

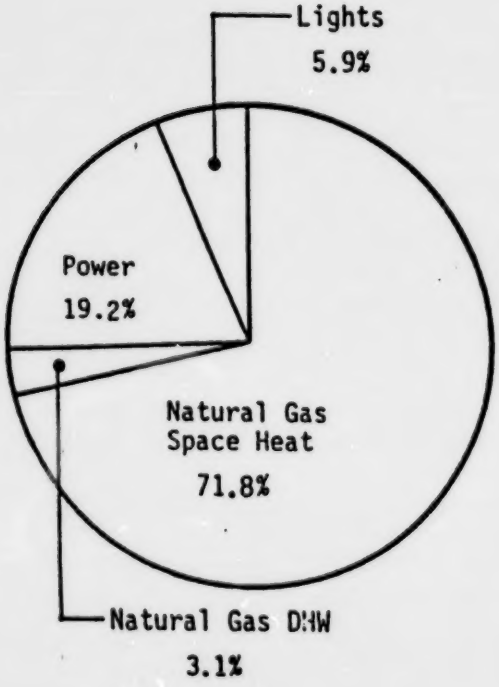
1983 PRE-RETROFIT ENERGY CONSUMPTION



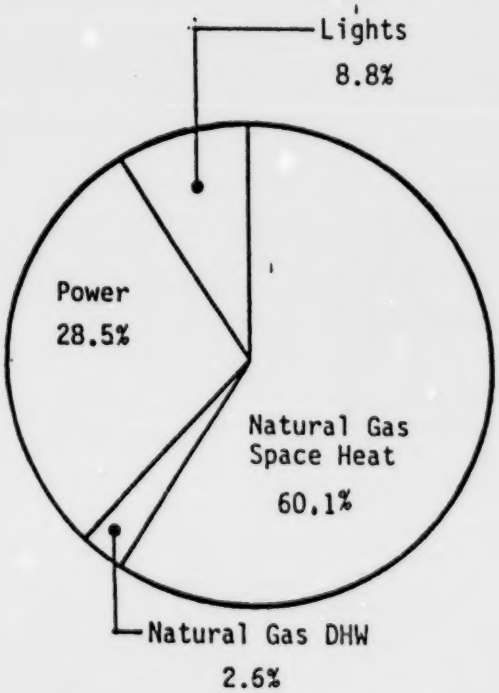
1983 PRE-RETROFIT ENERGY COST



1983 PRE-RETROFIT COMPONENT ENERGY CONSUMPTION



1983 PRE-RETROFIT COMPONENT ENERGY COST



PRE-RETROFIT ENERGY USAGE
BRANDON SPORTS COMPLEX

FIGURE 2.2

TABLE 2.2

SUMMARY OF ENERGY CONSERVATION TECHNIQUES DATA - BRANDON SPORTS COMPLEX

ECT	NAME	ESTIMATED CAPITAL COST $	ENERGY REDUCTION kWh/A	COST SAVING $/A	SIMPLE PAYBACK YRS.	CONSULTANT'S RECOMMENDATION	IMPLEMENTED BY
1	Maintenance Procedures	-	-	-	-	Y	Y
2	Filter Backwashing	-	26 600 (G)	358 (G) 313 (W)	Immediate	Y	Y
3	Demand Load Limiting	-	-	702 (D)	Immediate	Y	Y
4	Reduce Infiltration	-	-	-	-	Y	Y
5	Kitchen Exhaust	200	80 056 (G) 3 268 (E)	1 079 (G) 40. (E)	.2	Included with ECT-19	Included with ECT-19
6	Swimming Pool Recirc. Pump	150	39 350 (E)	484 (E)	.3	Included with ECT-19	Included with ECT-19
7	Photocell	150	-	10.83	13.9	N	N
8	Water Conservation	1 500	-	1 187 (W)	1.3	Y	Y
9	Night Setback	1 750	43 754 (G)	600 (G)	2.9	Included with ECT-19	Included with ECT-19

TABLE 2.2 - continued

SUMMARY OF ENERGY CONSERVATION TECHNIQUES DATA - BRANDON SPORTS COMPLEX

ECT	NAME	ESTIMATED CAPTIAL COST $	ENERGY REDUCTION kWh/A	COST SAVING $/A	SIMPLE PAYBACK YRS.	CONSULTANT'S RECOMMENDATION	IMPLEMENTED
10	Delamp	240	33 715 (E)	88 (E)	2.7	Y	Y
11	Upgrade Insulation	17.50/m²	48 kW/m²	.65/m²	27.0	N	N
12	Vestibule Entrance	10 000	44 515	600	16.7	N	N
13	Low Emissivity Paint	9 000				N	N
14	Electric Boiler	5 000	-171 900 (E) 229 320 (G)	-2 116 (E) 3 302 (G)	4.2	Y	Y
15A	Free Cooling of Brine	15 000		869 (E)	17.	N	N
15B	Heat Reclaim	54 100	1 294 196 (G) -500 655 (E)	23 258 (G) -3 238 (E)	2.7	Y	Y
16	Pool Blanket	11 600		4 836		Not Required Due to ECT 15	N
17	Dehumidifier (2)	141 500				Not Required Due to ECT 15	N

TABLE 2.2 - continued

SUMMARY OF ENERGY CONSERVATION TECHNIQUES DATA - BRANDON SPORTS COMPLEX

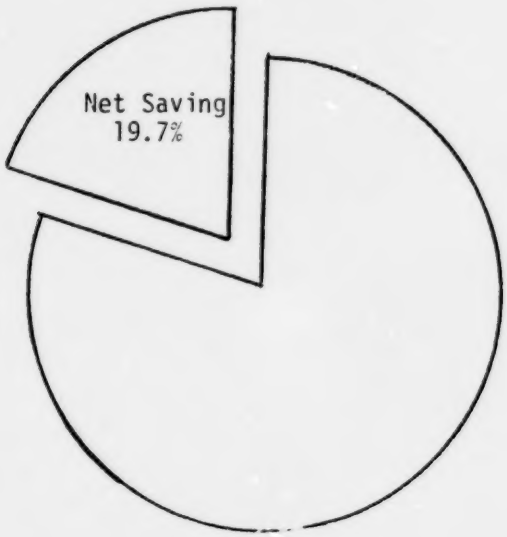
ECT -	NAME	ESTIMATED CAPITAL COST $	ENERGY REDUCTIONS kWh/A	COST SAVINGS $/A	SIMPLE PAYBACK YRS.	CONSULTANT'S RECOMMENDATION	IMPLEMENTED -
18	Solar	130/m²	428 kW/m² (G)	8.38/m²	15.5	N	N
19	Energy Management System	25 000	71 660 (E) 593 153 (G)	881 (E) 8 008 (G)	2.8	Y	Y
20	Power Factor Correction	3 410	-	1 127 (D)	3	Y	Y
Totals	Implemented ECTs	$89 300	2 140 000 (G) -567 000 (E)	$34 900 (G) $ 4 390 (E) $ 1 830 (D) $ 1 500 (W)	2.6 years	-	Y
	Consultant's Recommended ECTs	$89 300	2 140 000 (G) -567 000 (E)	$34 900 (G) $ 4 390 (E) $ 1 830 (D) $ 1 500 (W)	2.6 years	Y	-

Savings based on conservative estimate of 3 months operation of one compressor.

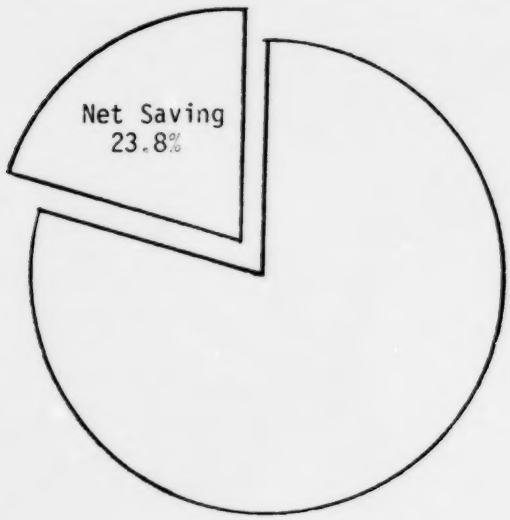
Parenthesis value relates to the particular saving.

- E Electrical Costs
- D Demand Charges only of Electric Cost
- G Gas Costs
- W Water Costs

PROJECTED POST-RETROFIT ENERGY SAVING



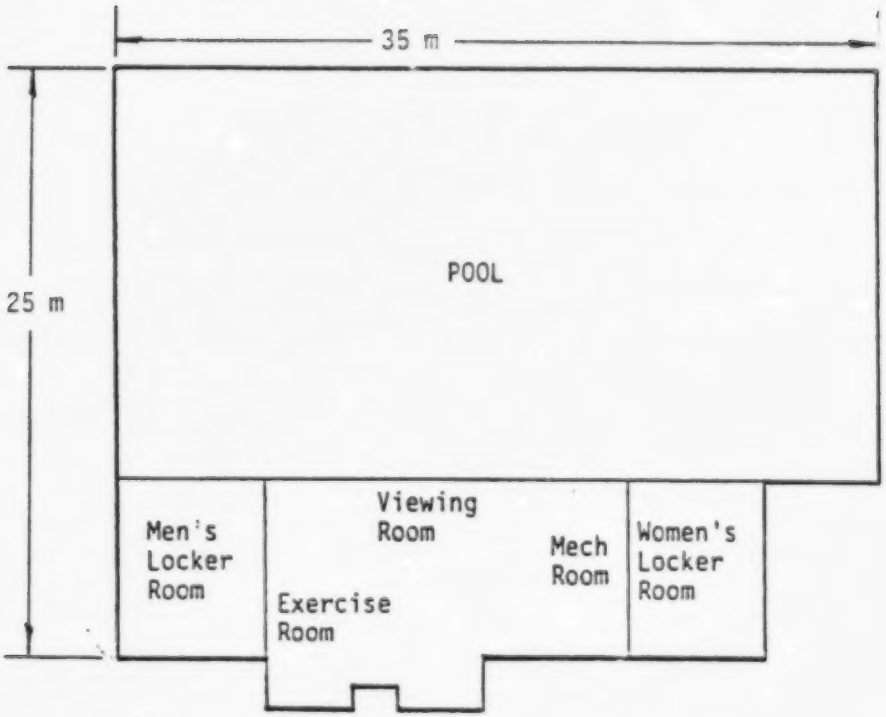
PROJECTED POST-RETROFIT COST SAVING



PROJECTED POST-RETROFIT SAVINGS
BRANDON SPORTS COMPLEX

FIGURE 2.3

3. Flin Flon Aqua Centre



PLAN VIEW

FLIN FLON AQUA CENTRE

FIGURE 3.1

N.T.S.

Propane and electricity are the two energy sources for the Flin Flon Aqua Centre. The 1983 pre-retrofit annual energy cost for the complex was $49 000. The energy consumption was in the range of 1.7 to 2.0 million kW.h annually, of which 83% was in the form of propane. The largest energy user was space heating (79%). The energy distribution is listed in Table 3.1 and illustrated in Figure 3.2.

Thirteen energy conservation techniques were evaluated. The results are summarized in Table 3.2. The twelve ECTs recommended by the Consultant to be considered for implementation are described briefly below:

ECT 1 Maintenance Procedures

Daily, weekly, monthly, yearly, and general maintenance procedures should be carried out.

ECT 2 Air Handling Units' Sequence of Operation

The two air handling units can be operated much more energy efficiently.

ECT 3 Stratification Fans

Stratification fans should be used properly: the rotational speed should be kept to a minimum and the fans should be turned off when no heating is required.

ECT 4 Swimming Pool Recirculation Pump

The pool recirculation pump should be turned off when the pool is not being used.

ECT 5 Night Setback

Energy can be saved by lowering the space temperature of the amenities area during any unoccupied periods.

ECT 6 Pool Makeup Water

The pool is losing an excessive amount of water. The source of this loss should be found to conserve heated water.

ECT 7 Roof Insulation

This is a facility upgrading recommendation: remove loose spray-type insulation on the pool roof and replace with an outside insulated roof system.

ECT 8 Pool Blanket

A pool blanket can be placed over the pool's surface during unoccupied periods to reduce the expensive evaporative losses.

ECT 9 Swimming Pool Dehumidifier

A dehumidifier removes moisture from the exhaust air thereby capturing the water's latent heat of vapourisation. This energy can be used to heat the pool water and room air.

ECT 10 Solar Heating

Government subsidies for solar energy projects may make solar energy a viable option.

ECT 11 Glycol Heat Reclaim

A glycol heat reclaim system can recover heat from the pool area exhaust air. This reclaimed energy can be used to preheat the outside air required to control the humidity of the pool area.

ECT 12 Heating with Propane vs. Electric

At the current rates, heating with propane is favoured over electric heat. The propane-fired equipment (except the pool heaters) should be converted to electricity.

Unfortunately, due to budget limitations, not all of the recommended ECTs could be implemented.
ECTs 4,6,8,10 and 11 were not implemented, as shown in Table 3.2. The resulting retrofit is summarized below.

Projected post-retrofit energy saving	5.8×10^5 kW.h/a (32%)
Projected post-retrofit cost saving	$17 600/a (36%)
Projected implementation cost	$120 000
Simple Payback Period	6.8 years

Figure 3.3 illustrates the expected savings in energy and cost. The long payback period for this facility's retrofit was caused by the installation of the insulated roof. This ECT was selected in order to upgrade the facility rather than because it had a favourable payback period.

In determining which of the recommended ECTs would not be carried out, the following reasoning was taken. A pool cover (ECT 8) is an excellent method of saving pool energy but putting it on and taking it off is a very tedious and labour intensive process. Though the larger dehumidifier (ECT 9) would yield an excellent return on investment, the capital cost is very high. Solar heating (ECT 10) was economical because of government subsidies but monies are better spent by first reducing energy losses before capturing free energy.

TABLE 3.1 1983 PRE-RETROFIT ENERGY CONSUMPTION DATA - FLIN FLON AQUA CENTRE

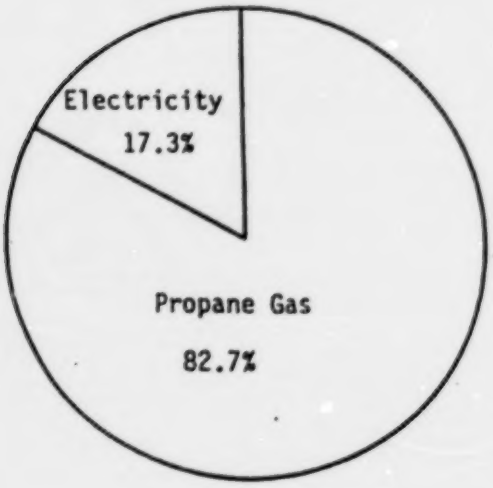
Location	Electricity Consumption (kWh)				Propane Consumption (kWh)			Total Consumption (kWh)
	Space Heat	Lights	Power	Total	DHW	Space Heat	Total	
Aqua Centre	11 500	182 673	132 107	326 280	61 385	1 492 980	1 554 345	1 880 625

TABLE 3.2

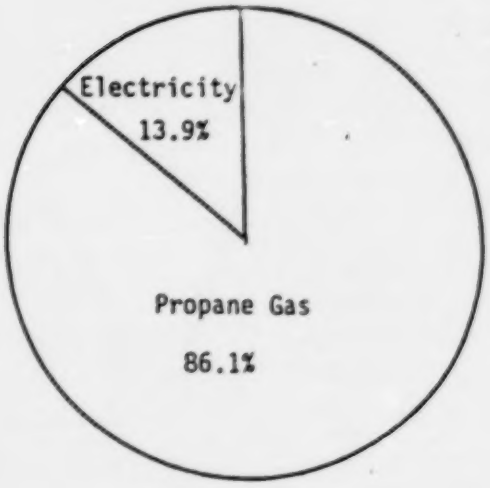
SUMMARY OF ENERGY CONSERVATION TECHNIQUES DATA - FLIN FLON AQUA CENTRE

ECT	NAME	ESTIMATED CAPITAL COST	ENERGY REDUCTION kWh/A	COST SAVING $/A	SIMPLE PAYBACK Yrs	CONSULTANT'S RECOMMENDATION	IMPLEMENTED
1	Maintenance Procedures	-	-	-	-	Y	Y
2	Air Handling Unit Sequence of Operation	-	-	-	-	Y	Y
3	Stratification Fans	-	-	-	-	Y	Y
4	Swimming Pool Recirc. Pump	200	19 481	240	8	Y	N
5	Night Setback	500	23 626	865	6	Y	Y
6	Pool Makeup Water	-	79 814	4 939	-	Y	N
7	Roof Insulation	49 200	46 596	2 437	20	Y	Y
8	Pool Blanket	6 900	139 525	5 165	1.3	Y	N
9	Swimming Pool Type 1 Dehumidifier Type 2	69 800 39 800	581 442 385 000	24 233 10 800	2.9 3.7	Y (preferred) Y	N Y
10	Solar Heating	(18 330) 6 110	58 156	2 129	8.6	Y	N
11	Glycol Heat Reclaim	10 000	87 951	3 220	3.1	Y	N
12	Heating with Propane vs Electric	30 000	123 000	3 500	8.6	Y	Y
13	Power Factor Correction	-	-	-	-	N	N
TOTALS	ECTs implemented	$120 000	578 000 kWh/A	$ 17 600	6.8 years	-	Y
	Consultant's Rec. ECTs	$173 000	1 160 000 kWh/A	$ 46 700	3.7 years	Y	-

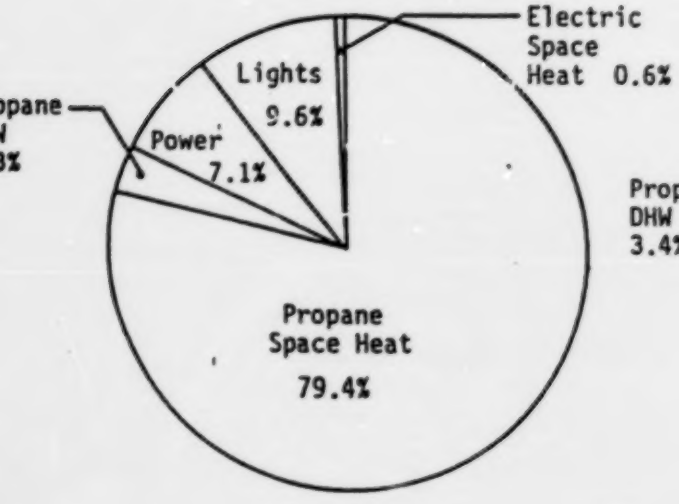
1983 PRE-RETROFIT ENERGY CONSUMPTION



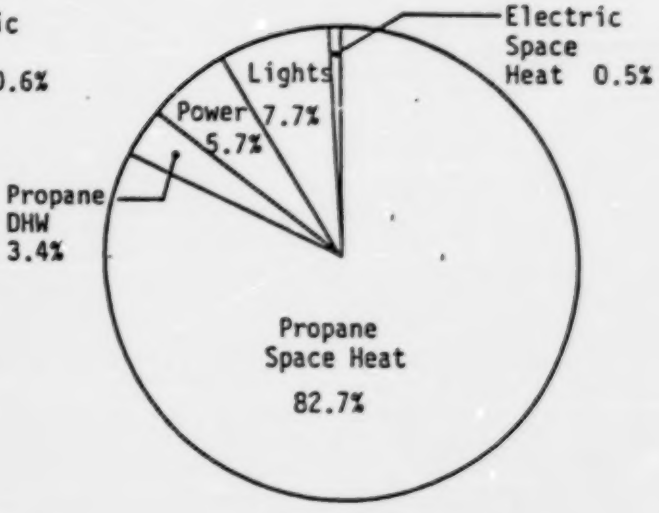
1983 PRE-RETROFIT ENERGY COST



1983 PRE-RETROFIT
COMPONENT ENERGY CONSUMPTION



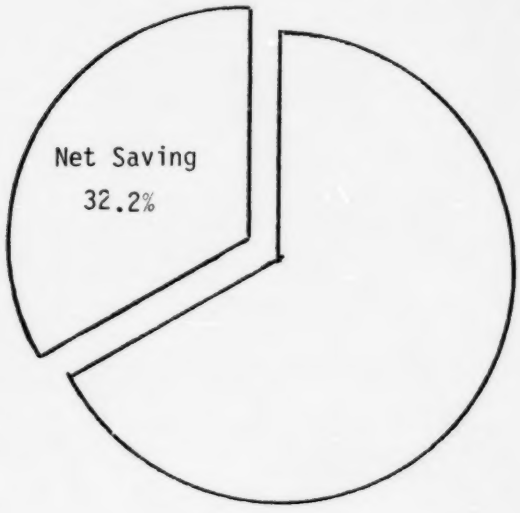
1983 PRE-RETROFIT
COMPONENT ENERGY COST



PRE-RETROFIT ENERGY USAGE
FLIN FLON AQUA CENTRE

FIGURE 3.2

PROJECTED POST-RETPOFIT ENERGY SAVING

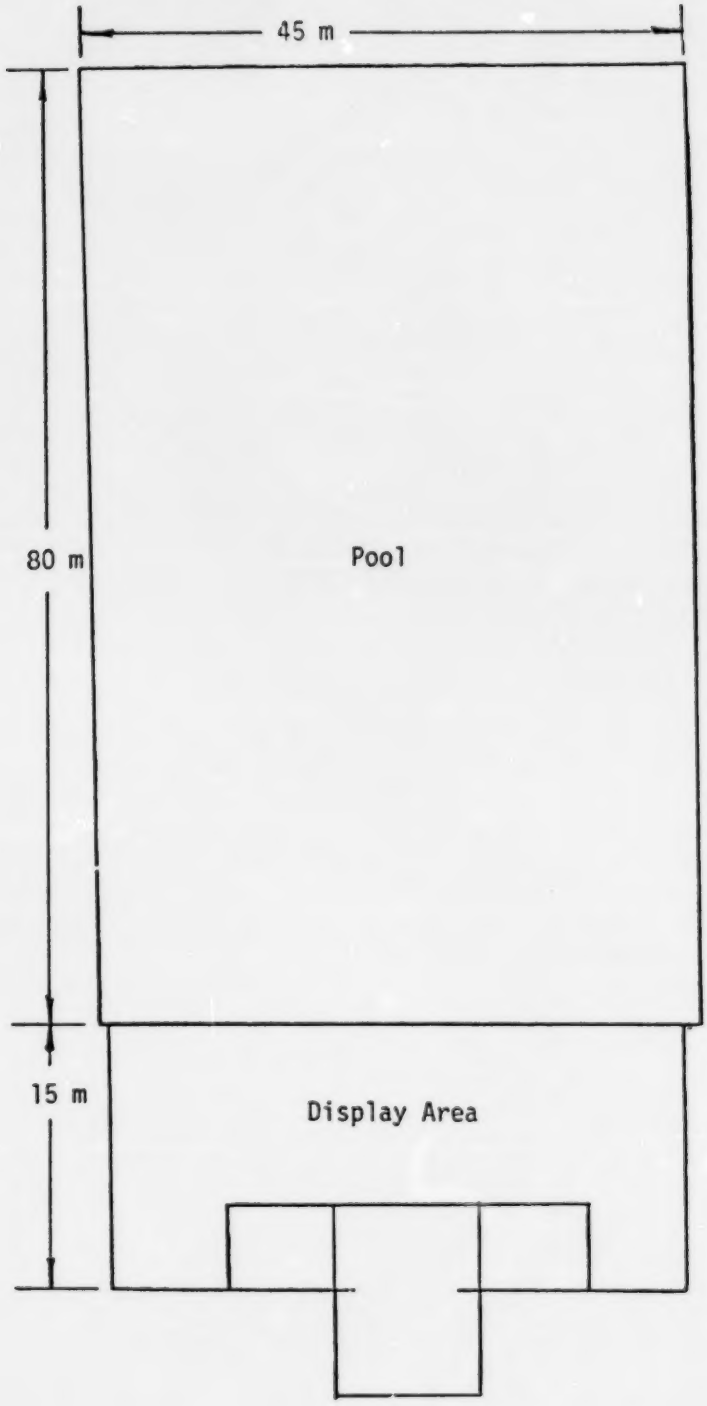


PROJECTED POST-RETROFIT COST SAVING

PROJECTED POST-RETROFIT SAVINGS
FLIN FLON AQUA CENTRE

FIGURE 3.3

4. Pan Am Pool



PLAN VIEW
PAN AM POOL

FIGURE 4.1

N.T.S.

Natural gas and electricity are the two sources of energy for the Pan Am Pool. The 1983 pre-retrofit energy cost for the complex was $231 500. The energy consumption, in the range of 9 to 11 million kW.h annually, was primarily in the form of natural gas (76%). Since the unit cost of natural gas is less than that of electricity, natural gas accounted for only 68% of the total energy bill. These figures are shown in Table 4.1 and illustrated in Figure 4.2.

Nineteen energy conservation techniques were evaluated by the Consultant as outlined in Table 4.2. Of these, it was recommended that thirteen be implemented. A brief description of these ECTs follows:

ECT 1 Maintenance Procedures

Daily, weekly, monthly, yearly and general maintenance procedures should be carried out.

ECT 2 Pool Filter

This is an experimental technique of cycling the pool pump, allowing the diatomaceous earth filter to realign and provide extra days of use before being replaced.

ECT 3 Delamping

Certain areas are overlit or improperly lit. Corrective measures should be taken.

ECT 4 Door Maintenance Procedures

The facility has many doors all of which require proper weatherstripping to reduce the excessive infiltration of cold outside air.

ECT 5 Low Flow Shower Heads

Restrictors placed on shower heads reduce hot water consumption.

ECT 6 Soffitt Space Infiltration Reduction

This is a retrofit measure aimed at conserving energy and increasing safety in order to reduce exfiltration of moisture-laden air and infiltration of cold outside air.

ECT 12 Glycol Heat Reclaim

Heat from the air exhausted from the pool area can be used to preheat the fresh outside makeup air.

ECT 13 Electric Boiler

An electric boiler used at a high duty cycle is more economical than natural gas.

ECT 15 Energy Management System

This facility can be connected to the City of Winnipeg's central microprocessor monitoring system. This will serve to optimise the functions of mechanical equipment and also give added security.

ECT 16 Rewiring of Electric Heaters

The electric infrared heaters can be used more economically to reduce demand charges.

ECT 17 Power Factor Correction

Adding capacitors to large motors or to the electrical service reduces the demand portion of the electricity bill.

ECT 18 Conversion to Fluorescent Lighting

The lighting in the changing rooms and mechanical room should be upgraded to higher energy conserving standards using fluorescent lighting.

ECT 19 Flood Lighting East Wall

Flood lighting the east wall of the facility would lower the vandalism of the glass.

All recommended ECTs, except ECT 19, were implemented. Note that ECT 8 - insulating the glass on the east wall - is to be re-evaluated by the City of Winnipeg for future consideration. The resulting retrofit is summarized below.

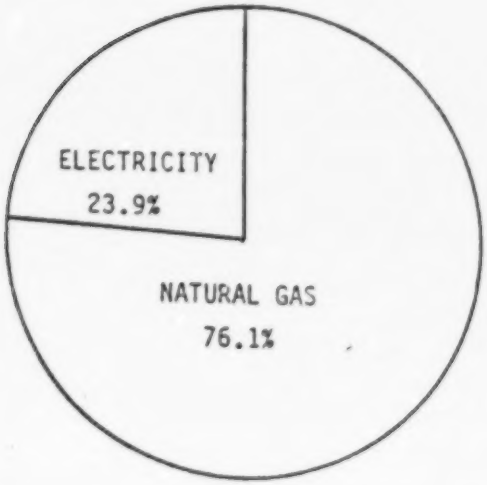
Projected post-retrofit energy saving	1.8×10^6 kW.h/a (18%)
Projected post-retrofit cost saving	$41 000/a (18%)
Projected implementation cost	$95 000
Simple Payback Period	2.3 years

Figure 4.3 illustrates the expected savings in energy consumption and cost.

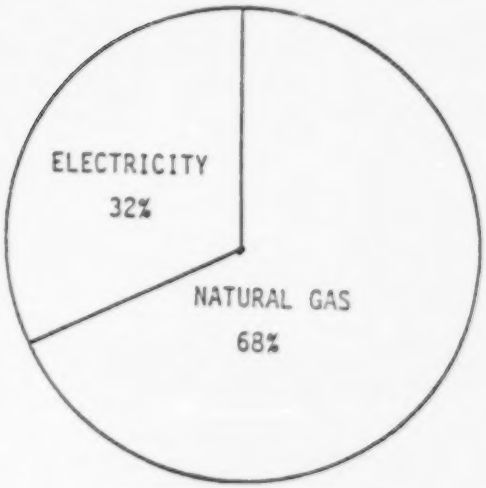
TABLE 4.1 1983 PRE-RETROFIT ENERGY CONSUMPTION DATA - PAN AM POOL

Electricity Consumption (kW·h)				Natural Gas Consumption (kW·h)			Total Consumption (kW·h)
Space Heat	Lights	Power	Total	DHW	Space Heat	Total	
246 375	645 044	1 468 581	2 360 000	1 010 357	6 512 503	7 522 860	9 882 860

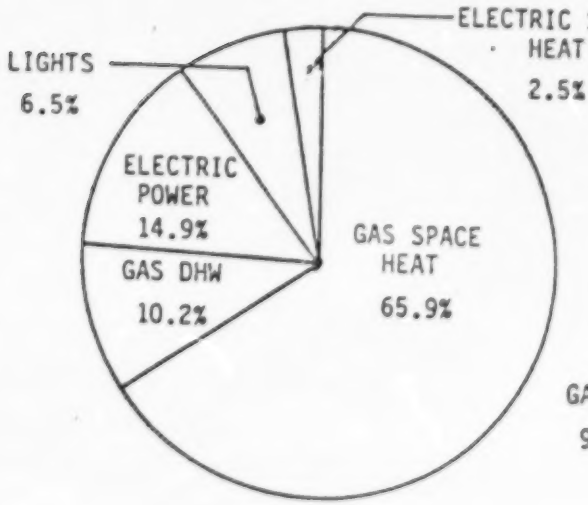
1983 PRE-RETROFIT ENERGY CONSUMPTION



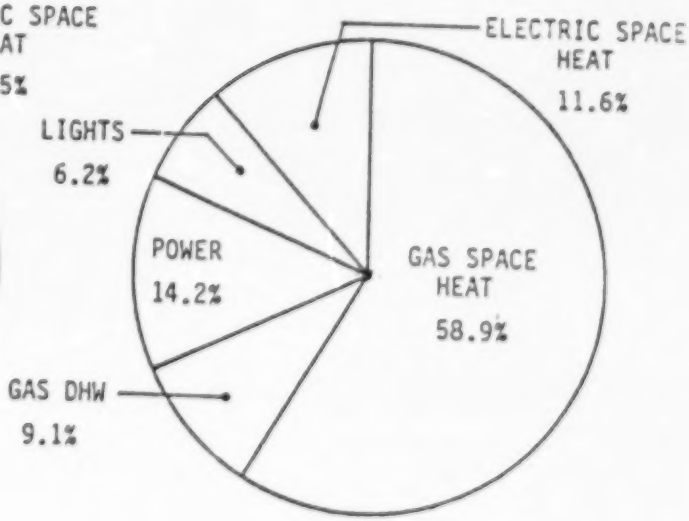
1983 PRE-RETPOFIT ENERGY COST



1983 PRE-RETROFIT COMPONENT ENERGY CONSUMPTION



1983 PRE-RETROFIT COMPONENT ENERGY COST



PRE-RETROFIT ENERGY USAGE
PAN AM POOL

FIGURE 4.2

TABLE 4.2

SUMMARY OF ENERGY CONSERVATION TECHNIQUES DATA - PAN AM POOL

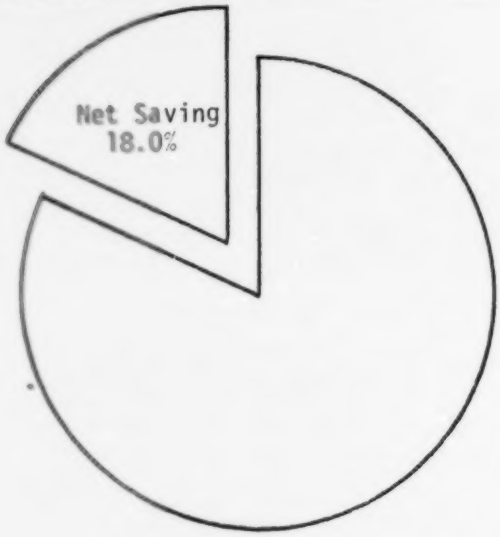
ECT	NAME	ESTIMATED CAPITAL COST $	ENERGY REDUCTION kW·h/a	COST SAVING $/a	SIMPLE PAYBACK yrs	CONSULTANT'S RECOMMENDATION	IMPLEMENTED
1	Maintenance Procedures	-	-	-	-	Y	Y
2	Pool Filter	-	-	-	-	Y	Y
3	Delamping	45	4 005(E)	54	.8	Y	Y
4	Door Maintenance Procedure	520	92 308(G)	1 430	0.4	Y	Y
5	Low Flow Shower Heads	720	404 144(G)	9 902	immediate	Y	Y
6	Soffitt Space Infiltration Reduction	30 000	153 846(G)	2 385	13.5	Y	Y
7	Insulation of Piano Windows	(10 000)	(59 097)	(916)	(10.9)	N	N
8	Insulation of East Wall	(70 000)	(589 820)	(13 131)	(5.3)	N	N
9	Pool Cover	(21 875)	(1 377 194(G))	(21 346(G)) (253(W))	(1.0)	N	N
10	Destratification Fans	(15 000)	(115 514(G)) (-21 024(E))	(1 790(G)) (-462(E))	(11.3)	N	N
11	Dehumidifier	(275 000)	(3 097 936(G)) (-987 760(E))	(48 006(G)) (-18 716(E)) (1 245(W))	(9.0)	N	N

SUMMARY OF ENERGY CONSERVATION TECHNIQUES DATA - PAN AM POOL

ECT	NAME	ESTIMATED CAPITAL COST $	ENERGY REDUCTION kW·h/a	COST SAVING $/a	SIMPLE PAYBACK yrs	CONSULTANT'S RECOMMENDATION	IMPLEMENTED
12	Glycol Heat Reclaim From Exhausted Air	19 650	289 870(G)	4 493	4.4	Y	Y
13	Electric Boiler	13 100	1 332 185(G) -784 200(E)	4 117	3.2	Y	Y
14	Solar Heated Pool	(130/m²)	(599 kW·h/m²)	($9.29/m²)	(14.0)	N	N
15	Energy Management System	7 800	59 225(E) 199 805(G)	4 148	1.9	Y	Y
16	Rewiring of Electric Heaters	5 000	-	10 004(D)	0.5	Y	Y
17	Power Factor Correction	8 000	-	2 700(D)	3.0	Y	Y
18	Conversion to Flourescent Lighting	10 400	59 000(E)	1 319	7.9	Y	Y
19	Flood Lighting East Wall	4 200	This is a facility upgrading	1 144	3.7	Y	N
TOTALS	Implemented ECTs	$95 200	2 470 000 (G) -662 000 (E)	$40 600/a	2.3 years	-	Y
	Consultant's Recommended ECTs	$99 400	2 470 000 (G) -662 000 (E)	$41 700/a	2.4 years	Y	-

PROJECTED POST-RETROFIT ENERGY SAVING

PROJECTED POST-RETROFIT COST SAVING



PROJECTED POST-RETROFIT SAVINGS
PAN AM POOL

FIGURE 4.3

Conclusion

The Urban Recreation Centre Retrofit Program was a success as suggested by the following figures. Energy and cost savings in each of the four urban recreation facilities were substantial: Energy savings ranged from 13 to 32% and cost savings from 18 to 36%. The estimated cost of implementation for the entire program was $412 000. The projected annual savings were $124 000 which represents a simple payback period of 3.3 years.

The success of this program demonstrates that recreational facilities are excellent areas in which to employ energy conservation technology. However, ECTs useful for one facility are often not beneficial for others so generalizations should be avoided. One should consult with Energy and Mines Manitoba or a specialized engineering firm.

The following four general classifications of energy conservation measures have emerged out of this study. These categories should help facility staff members recognize areas of potential energy saving. However, as mentioned above, recreational facilities vary so much from one to the next that each facility should be analysed individually. The cost of the following general techniques increases with each higher classification.

1. Reduce unnecessary energy use during unnoccupied periods

Typically, a facility is maintained to a level of comfort suitable to its occupants. If the building becomes partially or totally unoccupied, operational changes may be possible to reduce energy consumption. These include:

- reducing space temperatures to lower skin losses,
- covering pool surfaces to prevent evaporation,
- reducing the operating time of equipment such as ventilation fans,
- decreasing the outside air admitted into the building to reduce required heating or cooling, and
- using lights only when and where they are appropriate.

In general, any procedure that uses energy should be analysed to determine whether its energy consumption can be reduced or eliminated during unoccupied periods.

2. Improve building efficiency

The efficiency of every building component should be analysed. Out-of-date equipment should be substituted with high efficiency equivalents on a replacement basis. Lighting systems should be evaluated, especially high intensity systems over rinks and pools. The efficiency of the electrical system can often be improved by correcting the power factor of the system as a whole or of the individual components. With thorough maintenance, the efficiency of the building envelope can be kept high thereby minimizing expensive infiltration and exfiltration. Analysis of the products of combustion of furnaces and boilers can be used to increase the efficiency of their operation. All these examples are given as suggestions as to how one can improve the efficiency of the overall operation of a building.

3. Minimize energy costs

To minimize one's energy costs, one must have a total understanding of one's rate structures and the available energy sources.

An energy audit may reveal that the primary energy source used by the audited facility is the most expensive as was the case for the Flin Flon Aqua Centre. Usually, the least expensive energy will be obtained from a dual-fuel system - electricity providing the base loads and a combustible fuel satisfying peak demand.

When electricity is used without increasing the peak demand, its cost is less than an equivalent amount of energy in the form of natural gas, oil or propane. Proper scheduling of electrical equipment can therfore reduce energy costs. Further, any piece

of combustible fuel equipment has an operating efficiency associated with it of 50% to 90%. Electrical equipment not only can use a cheaper energy source but also uses less energy than the combustible fuel equipment which it can replace. As a final example of how you can save money without saving energy, electrical meters can be consolidated provided the demand charge is not increased excessively.

4. Reclaim wasted energy

In many processes, energy is thrown away to accomplish a task. This discarded energy can often be economically reclaimed. For instance, exhaust air can be used to heat the incoming fresh air by employing an air-to-air heat exchanger or a glycol run-around system. Spent shower water can preheat incoming cold water. Refrigeration plants usually throw away large amounts of heat in the condenser. This, too, can be recovered. Finally, pool dehumidifiers can recover a lot of the energy lost by pool water evaporation. These energy conservation measures require large capital expenditures.

The above classifications will help in identifying possible energy conservation measures for recreation facilities. Those in Section 1. tend to be free savings. ECTs in 2. require a small investment and the payback period is generally small. Those measures taken which are part of 3. may or may not need a large capital investment. The suggestions given in Section 4. are the most expensive retrofits. Professional help should be attained before implementing any of the major ECTs. The expense of implementing reasonable ECTs is well justified as has been demonstrated by the success of the Urban Recreation Centre Retrofit Program.

Appendices

CONCEPT: Many electric unit heaters in the C.A. Nesbitt Arena and the Gordon Beard Arena were oversized. Heating elements were disconnected to reduce the connected load by 75 kW. This reduced the electrical demand at the center by approximately 50 kVA.

SAVINGS: Based on:

- complete saving for 3 months
- 80% saving for 9 months
- $5.20/kVA/month demand charge

Consumption Saving

= 0

Demand Cost Saving

= 50 kVA x (3+9(.8)) months/yr x $5.20/kVA/month
= $2 650/yr

COST: $3 000

PAYBACK: = $3 000/$2 650/yr
= 1.2 years

CONCEPT: A 37 kW ice compressor for the C.A. Nesbitt Arena has limited service.

Two 75 kW heaters were interconnected with the compressor operation to provide heat in the lobby area when the compressor is off. Using this method, a demand charge is not incurred, and heating is obtained more cheaply than with the existing propane heater.

SAVINGS: Based on:

- 2800 hours of electric heater operation
- $0.0123/kWh electricity run out rate
- $0.030/kWh propane cost
- 80% boiler efficiency

Consumption Saving

= 30 kW x 2800 hours x (1/.8 -1)
= 21 000 kWh

Cost Saving

= (0.030/.8 - .0123) $/kWh x 30 kW x 2800 hrs/yr
= $2 100/yr

COST: $4 500

PAYBACK: $4 500/$2 100/yr
= 2.1 years

CONCEPT: The kitchen exhaust fan operated continuously. A time clock was installed to turn off the fan when the kitchen is not in use.

SAVINGS: Based on:

- fan can be shut off for 12 hours each day
- 275 day heating season
- 1 hp fan
- fan exhausts 755 L/Sec
- $0.014/kWh natural gas cost
- 70% boiler efficiency
- $0.0123 electricity runout rate
- 24.3°C average yearly temperature difference

Consumption Saving
= gas saving + electricity saving
gas saving = (1.21 W/ L/s -°C)(755L/s)(24.3°C)(kW/1 000 W)
(3 300 hrs/yr)(1/.7) = 105 000 kWh/yr
electricity saving = 4380 h/y (1hp) (.746 kW/hp)
= 3 270 kWh/yr

Consumption Saving
= 105 000 kWh/yr + 3 270 kWh/yr
= 108 000 kWh/yr

Cost Saving
= (105 000 kWh/yr) ($0.014/kWh) + (3270 kWh/yr)
($0.0123/kWh) = $1 420/yr + $40/yr
= $1 460/yr

COST: $200

PAYBACK: $200/$1 460/yr = 0.2 years

CONCEPT: The refrigeration equipment removes heat from the rink ice by transferring it to the atmosphere through the condenser. This situation was modified so that most of the energy is reclaimed to heat the domestic hot water and the outside air for the swimming pool air handling unit.

SAVINGS: Consumption Saving
= 800 000 kWh/yr

Cost Saving
= $20 000/yr

COST: $94 669

PAYBACK: $94 669/$20 000/yr
= 4.7 years

CONCEPT: During unoccupied periods space temperatures can be lowered to reduce heating costs. Night setback to 13°C for 7 hours each night was implemented in the amenities area of the Aqua Centre. A time clock and an additional thermostat were the only new equipment required.

SAVINGS: Based on:

- temperature setback to 13°C for 7 hours each night
- propane cost of 4.2c/kWh
- 80% boiler efficiency

Consumption Saving
= 16 500 kWh/hr

Cost Saving
= (16 500 kWh/yr) ($0.042/kWh)/0.80 eff
= $870/yr

COST: $500

PAYBACK: $500/$870
= 0.6 years

CONCEPT: A dehumidifier was installed to remove moisture from exhaust air, reclaiming the latent heat of vapourisation. The condensed water is returned to the pool, thereby reducing water consumption. The reclaimed energy is used to heat the ventilation air.

SAVINGS: Based on:

- propane cost of 4.2c/kWh
- 80% boiler efficiency

The anticipated consumption saving resulting from reduced makeup water, reduced makeup water heating and reduced ventilation air requirements was

Consumption Saving
= 240 000 kWh/yr

Cost Saving
= $12 600/yr

COST: $33 300

PAYBACK: $33 300/$12 600/yr
= 2.6 years

CONCEPT: Flow restrictors were placed on shower heads to reduce the domestic hot water consumption. An overall reduction of 40% was expected.

SAVINGS: Based on:

- 15 545 M^3/yr total annual hot water consumption
- 606 200 kWh/yr total hot water heating requirement
- natural gas cost of 1.55¢/kWh
- 70% boiler efficiency
- water cost of 0.585/M^3

Consumption Saving
= 0.40 x (606 200/0.7)kWh/yr
= 346 400 kWh/yr

Cost Saving
= (346 400 kWh/yr x $0.0155/kWh) + (15 545 M^3/yr x 0.4 x $0.585/$M^3$) = $5 370/yr + $3 640/yr
= $9 010/yr

COST: $720

PAYBACK $720/$9 010/yr
= 0.1 year

CONCEPT: Electricity used at a high duty cycle can cost less per kWh than natural gas. At the Pan Am Pool, a natural gas boiler operated at a low duty cycle during the summer months to meet the only heating load: the domestic hot water heating. Its efficiency during the summer was below 50%. A 108 kW electric boiler was added to the primary loop. It operates at a high duty cycle year-round.

SAVINGS: Based on:

- electric boiler has 95% duty cycle for 9 months and 40% duty cycle for 3 months
- natural gas boiler efficiency was 65% for 9 months and 45% for 3 months
- $0.0155/kWh natural gas cost
- $0.123/kWh electricity runout rate

Consumption Saving
= 784 000 kWh/yr

Cost Saving
= $3 300/yr

COST: $13 100

PAYBACK: $13 100/$3 300/yr
= 4.0 years

CONCEPT: Transformers, induction motors and any electromagnetic devices must be magnetised to function. This magnetising or inductive current does not produce any real work but does contribute to the total current. The ratio of the real current (kW) to the total current (kVA) is the power factor. Demand charge is based on total current which, for a given real current, is minimised when the power factor is unity. Power factor was improved by the addition of capacitors to the main electrical service.

SAVINGS: Based on:

- an 8% increase in power factor for 400 kVA.

Demand Saving
= 28 kVA/mo.

Cost Saving
= $1 800/yr

COST: $2 500

PAYBACK: $2 500/$1 800/yr
= 1.4 years

APPENDIX 2 - CONVERSION FACTORS

CONVERSION FACTORS*

Length
1 m = 3.281 ft
1 m = 3.937 × 10 in.

Area
1 m^2 = 1.550 × 10^3 $in.^2$
1 m^2 = 1.076 × 10 ft^2

Volume
1 m^3 = 6.102 × 10^4 $in.^3$
1 m^3 = 3.532 × 10 ft^3
1 m^3 = 2.642 × 10^2 U.S. gallons

Mass
1 kg = 2.205 lbm

Force
1 N = 2.248 × 10^{-1} lbf

Energy
1 J = 9.478 × 10^{-4} Btu = 7.376 × 10^{-1} ft-lbf
1 kW-hr = 3.412 × 10^3 Btu = 2.655 × 10^6 ft-lbf

Power
1 W = 3.412 Btu/hr
1 W = 1.341 × 10^{-3} hp
1 W = 2.844 × 10^{-4} tons of refrigeration

Pressure
1 Pa = 1.450 × 10^{-4} $lbf/in.^2$
1 Pa = 2.088 × 10^{-2} lbf/ft^2
1 Pa = 9.869 × 10^{-6} std atm
1 Pa = 2.961 × 10^{-4} in. mercury
1 Pa = 4.019 × 10^{-3} in. water

Temperature
1 deg R difference = 1 deg F difference = 5/9 deg C difference = 5/9 deg K difference
deg F = 9/5 (deg C) + 32

Velocity
1 m/s = 1.969 × 10^2 ft/min
1 m/s = 3.281 ft/sec

Acceleration
1 m/s^2 = 3.281 ft/sec^2

Mass Density
1 kg/m^3 = 6.243 × 10^{-2} lbm/ft^3

Mass Flow Rate
1 kg/s = 2.205 lbm/sec
1 kg/s = 7.937 × 10^3 lbm/hr

Volume Flow Rate
1 m^3/s = 2.119 × 10^3 ft^3/min
1 m^3/s = 1.585 × 10^4 gal/min

Thermal Conductivity

$$1\ \frac{W}{m\text{-}K} = 5.778 \times 10^{-1}\ \frac{Btu}{hr\text{-}ft\text{-}F}$$

$$1\ \frac{W}{m\text{-}K} = 6.934\ \frac{Btu\text{-}in}{hr\text{-}ft^2\text{-}F}$$

Heat Transfer Coefficient

$$1\ \frac{W}{m^2\text{-}K} = 1.761 \times 10^{-1}\ \frac{Btu}{hr\text{-}ft^2\text{-}F}$$

Specific Heat

$$1\ \frac{J}{kg\text{-}K} = 2.389 \times 10^{-4}\ \frac{Btu}{lbm\text{-}F}$$

Viscosity, Absolute

$$1\ \frac{N\text{-}s}{m^2} = 10^3 \text{ centipoise}$$

$$1\ \frac{N\text{-}s}{m^2} = 1\ \frac{N\text{-}s}{m^2} = 6.720 \times 10^{-1}\ \frac{lbm}{ft\text{-}sec}$$

Viscosity, Kinematic
1 m^2/s = 1.076 × 10 ft^2/sec
1 m^2/s = 10^6 centistoke

*All factors have been rounded off to four significant figures.